REMARKS:

Claims 57 to 72 are in the case and presented for consideration.

The attached page 10 was apparently missing from the copy of the Substitute Specification to the examiner. The undersigned has page 10 in the copy in his file. Page 10 contains the missing headings and is consistent with the marked up copy of the specification so that no new matter has been added.

The examiner's objections and rejection on formal grounds to the claims have been carefully reviewed and corrections incorporated into the newly submitted claims 57-72.

New independent claim 57 includes the subject matter of former claims 39, 48 and 52.

The remaining dependent claims contain the subject matter of respective claims 40-47, 49-51 and 53-56.

New claim 57 has been carefully drafted to avoid the objectionable relative terms which the examiner feels are unsupported by the specification.

Claims 48 and 52 quantify the hardness and tensile strength of the materials to be worked with the two types of tools manufactured according to the method of the invention. The first working material has a limited hardness and tensile strength and is worked by the first type of cutting tool. The second type of cutting tool is designed for cutting harder materials having greater tensile strength.

The dependent claims further characterize the method of the invention and are believed to further distinguish the invention over the prior art taken in any combination.

While the present invention has been rather difficult to claim, it is believed to be unobvious and certainly advantageous over the prior art. Looking through the eyes of the person of ordinary skill in the art and reading the prior art for what it teaches without the benefit of hindsight, it is believed clear that the inventors have contributed a patentable method as contemplated by 35 U.S.C. 102 and 103.

Leyendecker does in fact teach both coating types, namely (and following the examiner's definition) "homogeneous" and "inhomogeneous". This, with respect to the drill of Leyendecker's Example 1, where inhomogeneously coated drills are compared with homogeneously coated drills. Leyendecker finds that the drills with the coating of inhomogeneous type has a 50% higher life than drills coated with homogeneous coating.

Nevertheless, Leyendecker completely fails to specify **how** drilling was performed and especially on **which material** such drilling was performed.

It is most significant that Leyendecker's result with respect to drills are in opposition to the accurate results according ot the present application according to which drills of Example 3 with homogeneous coating (A) are significantly better by a factor of at least six, than drill with inhomogeneous coatings according to (B). The same result in shown by Example 6.

Applicants do not question the results of Leyendecker, but believe it is clear that Leyendecker's disclosure failed to teach **for which** drilling operations and for which material the improved drills with inhomogeneous coating are used. The inventors' experiments clearly show, contrary to Leyendecker's experiments, that Leyendecker's finding is only valuable if one specifies **for which** kind of operation and material, such drills are conceived. Lacking such specification makes Leyendecker's finding unusable because the results of Leyendecker's inhomogeneously coated drills will be significantly worse if applied to material, as disclosed by the present invention.

Therefore, although both methods, namely of homogeneously coating and of inhomogeneously coating, are known, it is not obvious to recognize **when homogeneous** coating and **when inhomogeneous** coating are to be applied to reach most favorable results. Therefore, the examiner's comment on the bottom of page 18 of the action is not agreed with.

The Examiner is respectfully requested to telephone the undersigned for the purpose of scheduling a telephone interview to discuss this case.

Respectfully submitted,

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BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be explained with reference to examples and, in connection therewith, to the drawing, wherein:

Fig. 1 is an Auger line scan diagram, recorded in the active edge region, by example of an indexable insert of type SNGA 120408, at right angles to the active edge, the titanium and aluminum distribution being recognizably uniform, corresponding to an unchanged composition of the hard material layer in the active edge region;

Fig. 2 is an Auger line scan diagram recorded on the same object as in Figure 1, however, on which the titanium and aluminum distribution in the active edge region is of changed composition of the material of the hard material layer; and

Fig. 3 is a simplified and schematically diagram of a view onto an installation used for the described experiments.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the discussed examples, identical basic tool bodies were in each instance coated by means of arc vaporization. In examples 1 to 4 the coating conditions specified in the following by A and B were selected. The layer thickness, in particular in the active edge region, was approximately 3.5 µm.

The coatings realized under A show a uniform titanium or aluminum distribution according to the Auger line scan of Figure 1. It was recorded starting on the edge of an indexable insert of Type SNGA 120408 coated according to A at right angles to the active edge or the polished machining face to a length of 0.5 mm, corresponding to approximately 60 measuring points per scan. The hardness of the layers realized under A was approximately 3000 $HV_{0.05}$.

The parameters described under B yield layers which in the active edge region (that is on either side of the edge proper) and have a strong depletion of the aluminum, namely from 50 at% (on the edge) to 40 at%, or an enrichment of titanium from 50 at% (on the edge) to 60 at%, according to Figure 2. With more sharply pronounced edges, such as for example in the case of knife cutters, markedly greater differences in the material composition of the hard layer could be measured. The hardness of the layers deposited under B is approximately 3500 $HV_{0.05}$. In the following tables, the two parameter sets A and B for the arc vaporization coating are summarized.

All experiments were carried out on an installation BAJ 1200 under production conditions.

In Figure 3 the view onto an installation of the given type is shown schematically. In a cylindrical treatment chamber 1 a revolving table is supported rotatably with respect to the central axis A_1 as shown with the rotational motion ω_1. On the revolving table several substrate carrier arrangements 3 are supported each rotatable about axes A_2, as is shown with the

rotational motion ω_2. On the substrate carrier arrangements 3 are supported in individual substrate carriers the substrates 5 grouped about the particular axis A_2, which substrates are preferably themselves, and as shown with ω_3 driven about their own axis, set into rotational motion.

Onto the wall of the chamber 1 are flanged one or several arc vaporizer sources 7. With respect to the specific and detailed structure of the installation used, reference is made for example to US A 5 709 784 by the same applicant.

In the experiments exclusively N_2 gas was used, *i.e.* as the working gas as well as also the reactive gas. It is understood that additionally also an inert gas, in particular argon, can be used as the working gas. For the coating of type A the total pressure, *i.e.* the N_2 pressure, was approximately 3 x 10^{-2} mbars, for the experiments B approximately 1 x 10^{-2} mbars.

Ti, Al was arc-vaporized from alloy targets.

In the following tables denote further:

p_{N2} : partial pressure of reactive gas N_2

I_{Ti} : arc current during titanium vaporization

I_{TiAl} : arc current during TiAl alloy vaporization

Coating Parameters A:

Parameter	**TiN Intermediate Layer**	**(TiAl)N Hard Material Layer**
p_{N2} [mbar]	8×10^{-3}	3.2×10^{-2}
I_{Ti} [A]	170	0
I_{TiAl} [A]	0	200
U_{BIAS} [V]	-200	-40

Coating Parameters B:

Parameter	**TiN Intermediate Layer**	**(TiAl)N Hard Material Layer**
p_{N2} [mbar]	8×10^{-3}	1×10^{-2}
I_{Ti} [A]	170	0
I_{TiAl} [A]	0	200
U_{BIAS} [V]	-150	-150

In all cases a TiN intermediate layer was installed between basic tool body and hard material layer.

Example 1

Tool : Turning tools with indexable insert K313/CNGP432

Material worked : AISI 304SS ≅ DIN 1.4306

Cutting rate : v_c = 244 m/min

Advance per rotation : f_u = 0.2 mm/r

Cutting depth : a_p = 1.524 mm

Lubricant : emulsion

Example 3

Tool : HSS drill, 6 mm

Material worked : AISI D3 ≅ DIN 1.2080

Cutting rate : v_c = 35 m/min

Advance per rotation : f_U = 0.12 mm/r

Engagement size : a_e = 3 mm

Drilling depth : h = 15 mm, pocket hole

Lubricant : 5% emulsion

Experiment No.	**Layer**	**Average Number of Holes**
28	TiN	45
29	TiCN	85
30	TiAlN "A"	190
31	TiAlN "B"	30

Examples 1, 2 and 3 show that for specific tools and conditions of use a composition of the hard material changed in the active edge region, in particular depletion of Al, leads to markedly poorer service lives than an unchanged composition of the hard material layer.

Example 4a

Tool : Hard metal roughing shank-type milling cutter, ∅ = 10 mm, 25/64

Teeth number : z = 4

Material worked : DIN 1.2344, 55-56 HRC

Cutting rate : v_c = 50 m/min

Advance per rotation : f_t = 0.02 mm/tooth

Engagement size : a_e = 2 mm

Cutting depth : a_p = 10 mm

Lubricant : dry, compressed-air cooling

Experiment No.	Layer	Wear Width in µm after x Operations			
		x = 10	x = 20	x = 30	x = 35
22	TiAlN "A"	45	54	65	70
23	TiAlN "B"	50	69	80	88

This example shows especially hard conditions of use since hard material is worked dry. The tools coated with the parameters A and consequently tools with unchanged composition of the hard material layers in the active edge region show markedly lower wear mark widths than tools with changed composition of the hard material layer in the active edge region.

Example 4b

Tool : Hard metal roughing shank-type milling cutter, ⌀ = 10 mm, 25/64

Teeth number : z = 3

Machined material : DIN 1.2311, 33 HRC, Rm = 1050 N/mm^2

Cutting rate : v_c = 100 m/min

Advance per rotation : f_t = 0.035 mm/tooth

Engagement size : a_e = 3 mm

Cutting depth : a_p = 16 mm

Lubricant : 5 % emulsion

Experiment No.	Layer	Average Length of Path

24	TiN	24
25	TiCN	27
26	TiAlN "A"	42
27	TiAlN "B"	78

This example makes evident that at high cutting rate and additional emulsion lubrication, further with relatively soft material to be worked, on average greater path lengths are achieved with the coating technique according to B.

Consequently, Examples 4a and 4b show that in similar operations but different conditions of use, identical tools coated differently in the active edge region are advantageous in each instance.

In the following Examples 5 to 9 further tools are specified with the particular applicable coating parameters analogous to A and B. Those tools with constant composition of the hard material layer in the active edge region are denoted by A_0, analogous tools with changed composition of the hard material layer in the active edge region by B_0. Apart from the specified coating parameters, identical basic tool bodies were coated with identical coating processes and compared with one another with respect to their service life.

Example 5

Tool : milling cutter with indexable inserts SEE 42 TN (G9)

Teeth number : $z = 6$

Layer thickness $(Ti_xAl_y)N$: each 4.5 µm

Material worked : SKD 61 (HRC45)

Cutting rate : v_c = 100 m/min

Advance per tooth : f_z = 0.1 mm/tooth

Cutting depth : a_p = 2 mm

Samples	No.	Coating Conditions			Al decrease toward edge [at%]	Cutting length [m]
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	32	60	2.5	150	1	3.2
	33	60	3.2	150	1	3.0
	34	40	2.0	150	0	8.8
	35	40	4.0	150	0	3.9
	36	40	0.5	150	0	2.0
	37	30	2.0	150	0	4.2
B_0	38	100	2.0	150	4	1.1
	39	150	3.0	150	7	1.1
	40	150	2.0	150	4	0.5

Example 6

Tool : HSS drill, ⌀ 6 mm

Layer thickness $(Ti_xAl_y)N$: each 5 µm

Intermediate TiN layer : each 0.5 µm

Material worked
(with emulsion) : DIN 1.2080 (AISI D3)

Cutting rate : v_c = 40 m/min

Advance : f = 0.10 mm/r

Drilling depth : 15 mm (pocket hole)

Samples	No.	Coating Conditions			Al decrease toward edge [at%]	Number boreholes
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	41	40	3.0	200	0	198
	42	40	3.0	200	0	231

B_0	43 44	150 150	1.0 1.0	200 200	7 7	45 38

<u>Example 7</u>

Tool : HSS roughing milling cutter, ⌀ 12 mm

Number of teeth : $z = 4$

Layer thickness $(Ti_xAl_y)N$: each 4.5 µm

Intermediate TiN layer : each 0.3 µm

Material worked dry : DIN 1.2344 (AISI H13)

Cutting rate : v_c = 120 m/min

Advance per tooth : f_z = 0.6 mm/tooth

Cutting depth : a_p = 20 mm

Engagement size : a_e = 5 mm

Samples	**No.**	**Coating Conditions**			**Al decrease toward edge [at%]**	**Cutting length [m]**
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	45	40	2.5	200	0	41
B_0	46	150	1.0	200	7	12

<u>Example 8</u>

Tool : Hard metal drill, ⌀ 11.8 mm

Layer thickness $(Ti_xAl_y)N$: each 5 µm

Intermediate TiN layer : each 0.5 µm

Material worked
(with emulsion) : GG 25 (gray cast iron)

Cutting rate : v_c = 110 m/min

Advance : f = 0.4 mm/r

Drilling depth : 35 mm (pocket hole)

Samples	**No.**	**Coating Conditions**			**Al decrease toward edge [at%]**	**Number boreholes**
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	47	40	3.0	200	0	2840
B_0	48	150	1.1	200	7	1270

Example 9

Tool : Hard metal indexable insert, external turning

Layer thickness $(Ti_xAl_y)N$: each 5 µm

Intermediate TiN layer : each 0.2 µm

Material worked
(with lubrication) : DIN 1.4306 (X2CrNi 1911)

Cutting rate : v_c = 240 m/min

Advance per rotation: f = 0.6 mm

Cutting depth : a_p = 1.5 mm

Samples	No.	Coating Conditions			Al decrease toward edge [at%]	Cutting length [m]
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	49	40	3.0	200	0	4.732
B_0	50	150	1.0	200	7	2.015

The Examples 5 to 9 show the superiority of tools with unchanged hard material layer composition in the active edge region in different spectific applications.

Example 10

Tool : Hard metal front-end milling cutter, ⌀ 10 mm

Tooth number : $z = 6$

Layer thickness $(Ti_xAl_y)N$: each 3.5 µm

Material worked dry AISI (DIN 1.2379), 60 HRC

Cutting rate : $v_c = 20$ m/min

Advance per tooth : $f_z = 0.035$ mm/tooth

Cutting depth : $a_p = 15$ mm

Engagement size : $a_e = 1$ mm

Samples	**No.**	**Coating Conditions**			**Al decrease toward edge [at%]**	**Cutting length [m]**
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	51	40	3.0	200	0	4
	52	40	2.0	200	0	2
	53	20	2.0	200	0	3
	54	70	3.0	200	1.5	12
B_0	55	200	3.0	200	9	21
	56	150	2.0	200	7	29
	57	100	1.0	200	4	17
	58	100	2.0	200	4	22

Example 11

Tool : Hard metal front-end milling cutter, ⌀ 10 mm

Tooth number : $z = 6$

Layer thickness $(Ti_xAl_y)N$: each 3.5 µm

Intermediate TiN layer : each 0.1 µm

Material worked DIN 1.2379 (AISI D2), 60 HRC

Cutting rate : $v_c = 20$ m/min

Advance per tooth : $f_z = 0.03$ mm/tooth

Cutting depth : $a_p = 15$ mm

Engagement size : a_e = 1 mm

Samples	No.	Coating Conditions			Al decrease toward edge [at%]	Cutting length [m]
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	55	40	3.5	200	0	22
B_0	56	150	1.0	200	7	31

Example 12

Tool : Hard metal ball-end milling cutter J97 (Jabro), R4 (⌀ 8 x 65 mm)

Layer thickness $(Ti_xAl_y)N$: each 3.5 µm

Intermediate TiN layer : each 0.1 µm

Material worked dry : DIN 1.2343, 49.5 HRC

Cutting rate : v_c = 240 m/min

Cutting depth : a_p = 0.5 mm

Samples	No.	Coating Conditions			Al decrease toward edge [at%]	Cutting length [m]
		Bias [-V]	N2 [10^{-2} mbars]	Arc Current [A]		
A_0	57	40	3.0	200	0	111
B_0	58	150	1.0	200	7	168

Examples 10 to 12 show that under certain application conditions and with specific tools the service lives are increased if the composition of the hard metal layer is changed in the active edge region.